Extrusion Pressure Testing

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Abstract

We present a first look at which pressure tests should be done, and how to perform them at the extruder factory.

Introduction

NOVA will be assembled from 23,808 extrusions, each 1.3064 m wide, 66 mm thick, and 15.8 m long, weighing 256 kg when empty.

We have identified one possible, though very unlikely, failure mode,

An extrusion or material defect can weaken the webs between extrusion cells to such an extent that they tear when pressurized by the scintillation oil after installation.

If such a failure should occur, it is conceivable that many additional extrusions can be stressed beyond the PVC allowable stresses.

It is difficult to simulate this failure mode, since a model would have to be extremely extensive in all 3 dimensions.

We take the approach to do sufficient pressure testing to reduce the likelihood of this failure to an acceptable level.

What to Test, Where, and How Often

At first blush, it seems desirable <u>to test all extrusions</u>, preferably before they are outfitted into modules. This scheme has two drawbacks:

- a. The extrusions are very long and heavy. A test bed would be over 50 ft long, cumbersome, and expensive. Handling is expensive.
- b. Testing even to moderate over-pressures deforms the extrusions permanently and very quickly. Large overpressures, possible to bursting, are desirable to make the test sensitive to incipient problems.

Alternatively, one can test <u>short extrusion lengths</u> and discard the samples after testing. By testing one short sample between all production extrusions, each extrusion is bracketed by tests.

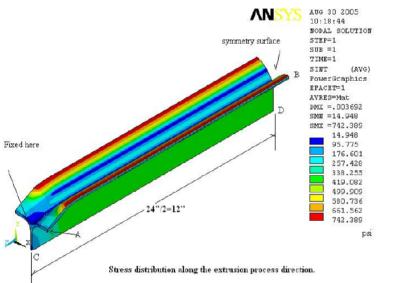
This is the approach we are presenting here. Catastrophic extrusion failure is unlikely to be in just one spot; one can reasonably expect that a fair length of extruded product will be similarly affected. Periodic sampling will detect this condition.

Sample Length and Preparation

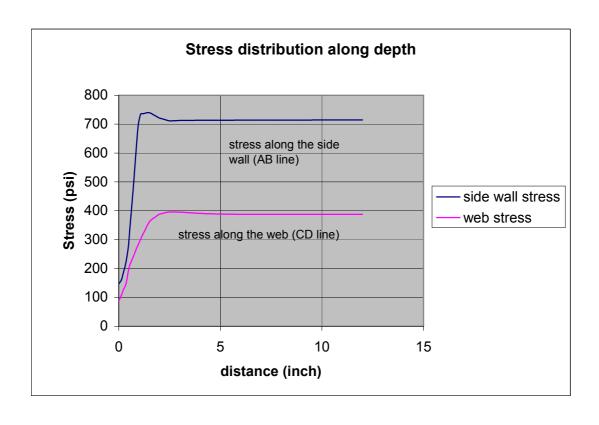
The sample under test is sealed by pressing an end plate, lined with a half inch thick rubber sheet, against each end of the cut extrusion to seal it.

One of the rubber sheets is slotted to create a channel which carries compressed air to all cells

One might be concerned the rubber sheets constrain the ends of the extrusion and distort the test results. We have done an FEA analysis under the conservative assumption that the ends of the extrusion are held immobile during the test:



Total length is 24" (2 ft). Only 12" is used for the calculation due to the symmetry



We see that the end-effect due to the end constraint extends no more than 2 inches from each end. An 8 inch long sample will have 4 inches of length unaffected by the ends. We have pressure tested a sample of our small 3-cell extrusion (1 inch thick x 5 1/8 inches wide) between rubber-lined aluminum plates, clamped by two threaded rods. This sample was tested to 90 psi, where a leak stopped us (the leak was due to a misalignment of the rubber with the extrusion). The extrusion sample was permanently deformed, with the outer sheath bowing out between webs. Inspection shows clearly that the rubber sheet did not influence the deformation shape at all. This means that the full length of the sample is tested with full accuracy. Samples shorter than 8 inches long will be usable.

Sample Cost

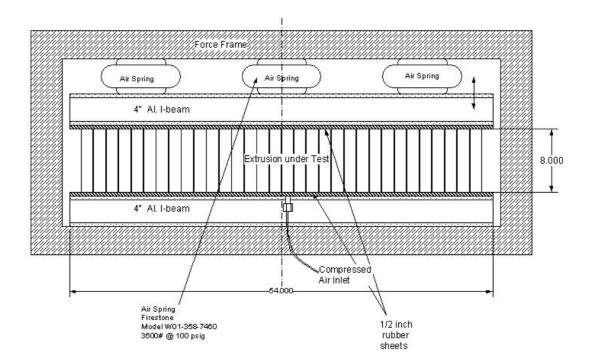
If we test one sample between all extrusions, then we will test 23,809 samples. If the samples are 8 inches long, we will test (8"/53 ft) = 1.26 % of the PVC material, for a total of (0.01258*5,970,000kg) = 75,000 kg, at a cost (scaled from the 2005 proposal) of (75,000kg)*(2.376 s/kg) = \$178,400.

This cost can be reduced by testing fewer samples, or by testing shorter samples.

Test Equipment

An extremely large number of samples will be tested.

In the interest of reliable QA, cost containment, and simplicity of training, we propose an automated test station. The test station can be built at modest cost (around 15 k\$ each), and would be located at all extruder companies. Extruder personnel would operate and perform the tests. Results would be stored in an attached computer and backed up onto CD's.



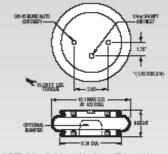
Extrusion Pressure Tester

Hans Jostlein 9/2/2005

AIRSTROKE AIRMOUNT Forestone 115

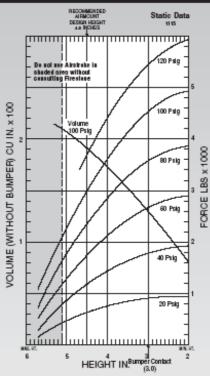
	Description	Assembly Order No.	
Style 115 Two Pty Bellows	Blind nuts, 1/4 NPT	WO1-358-7460	
	Blind nuts, 1/4NPT rubber bumper	WO1-358-7459	
	Blind nuts, 3/4 NPT	WO1-358-7485	
	Blind nuts, 3/4 NPT rubber bumper	WO1-358-7458	
	Countersunk steel bead rings, 1% bolts, nuts, washers	WO1-358-7469	
	Blind nuts, 3/4 NPT both ends (centered)	W01-808-7115	
I	Rubber belows only	WO1-358-0118	
Assembly weight			
Force to collapse to minimum height (@ 0 PSIG) 8 lbs.			

484	·	WO1-358-7650 WO1-358-7640
Strength		



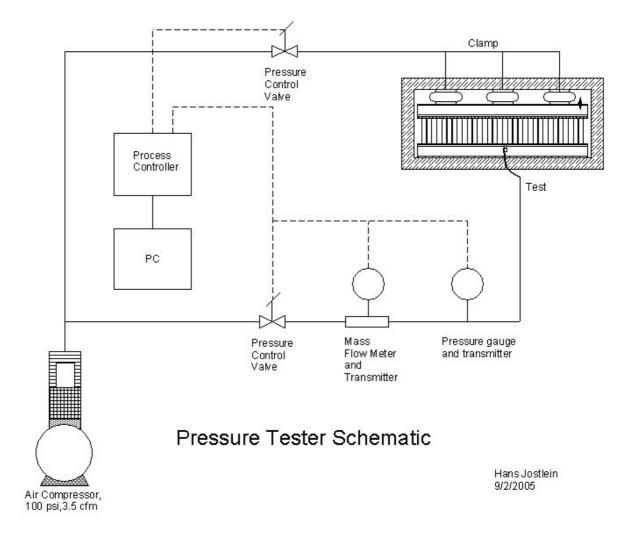
NOTE: A bead plate part is shown. This part is also available with bead rings. See pages 8-10 for explanation.

Dynamic Characteristics at 4.5 in. Design Height (Required for Alimount isolator design only)							
Volume @ 100 PSIG = 192 In1			Natural				
Gage		Spring	Frequ	iency			
(PSIG)	(bs.)	Rate (lbs/in.)	СРМ	HZ			
40	1,180	1,008	174	2.80			
60	1,750	1,417	169	2.81			
80	2,350	1,846	166	2.77			
100	3,010	2,257	163	2.71			



See page 12 for instructions on how to use chart.

Force Table (Use for Airstroke* actuator design)							
Amenbly Height (In)	Volume en 100	Pounds Force					
	PSIG (M ³)	@20 PSIG	e 40 PSIG	eso PSIG	Ø80 PSIG	@100 PSIG	
5.0	207	460	840	1,290	1,790	2,270	
4.0	173	740	1,440	2,150	2,870	3,640	
3.0	190	890	1,760	2,650	3,550	4,520	



Samples are dropped into the Force Frame, which sits in a sound insulated box. The top of the box is formed from a steel grating, lined with a polycrbonate shield on the inside, to protect against flying debris. The cover must be closed before pressure can be applied.

A set of three air springs is used to clamp the end plates and rubber sheets against the open ends of the extrusion.

After clamping, air pressure is slowly increased to the inside of the extrusion. A pressure gauge and mass flow meter track the changes, and transmit their data to a process controller.

A possible measurement sequence might be:

- —clamp seal plates
- --apply 5 psi
- --check for leaks by watching mass flow go to zero (stop the test if a leak is detected)

- --apply 20 psi (experiment working pressure)
- --watch air flow for one minute for leaks and/or creeping. No creep is allowed at this pressure
- --repeat last at 30 psi
- --repeat at 50 psi; some creep should appear
- --repeat at 70 psi
- --repeat at 90 psi or till burst occurs

Mass flow data will be corrected for pressure and temperature by the attached computer.

They give direct information about extrusion volume changes, .e.g. due to creep or aneurysm type web failure.

The computer assigns an extrusion ID (e.g. based on date and time) and prints two copies of a summary page, including a go-no go determination.

One sheet is attached to the extrusion, the other added to the traveler.

Additional Tests

Additional tests will be needed. They include stress/strain curves and reflectivity measurements. Large extruders are expected to own INSTRON type testers. For reflectivity we have identified hand held instruments that will be evaluated shortly.